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AUTHOR Vorwerk, Katherine E.
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ABSTRACT

The present research was designed primarily to investigate the type of instruction needed to help children learn difficult principles. A total of 159 fifth graders (each assigned to one of six experimental conditions) read lessons which dealt with principles from two content areas (mathematics and language arts). Lessons varied in the number of instances used to illustrate the principles and the presence or absence of instruction on concepts related in the principle. Learning was measured by four tests designed to assess student's knowledge of and ability to apply the principles. Results suggested that a rationally selected set of examples and non-examples is more facilitative than one example, although one example may be sufficient, if the principle is simple and instruction is provided on concepts related in the principle. (Author/GO)

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INSTRUCTIONAL FACTORS RELATING TO CHILDREN'S PRINCIPLE LEARNING

Katherine E. Vorwerk

The Catholic University of America

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Abstract

Fifth-grade students read lessons dealing with principles from two content areas. Lessons varied in the number of instances used to illustrate the principles and the presence or absence of instruction on concepts related in the principles. Learning was measured by tests designed to assess students' knowledge of and ability to apply the principles. It was concluded on the basis of application item results that a rationally selected set of examples and non-examples is more facilitative than one example, although one example may be sufficient if the principle is simple and instruction on concepts related in the principle is provided.

Instructional Factors Relating to Children's Principle Learning

Conceptual learning and development has become a topic of increasing interest to both psychologists and educators in recent years. A large and growing body of literature in the area comprising a variety of theoretical viewpoints and empirical investigations currently exists. Additionally, several practical applications of existing knowledge to the classroom teaching situation have been proposed (Klausmeier & Feldman, 1975; Klausmeier, Ghatala, & Frayer, 1974; Markle & Tiemann, 1969, 1972; Tennyson, Woolley, & Merrill, 1972).

The great majority of the literature on concept learning, however, deals with the acquisition of discrete, isolated concepts. While many concepts may indeed be learned in isolation, particularly during the early years of life, a large number of concepts taught in the schools and acquired by adults are not learned in isolation but rather as part of a "principle" (i.e., "rule" or "law") that specifies a relationship among several concepts. How principles are learned and can be taught most effectively is thus a topic of some importance.

Necessary conditions of principle learning have been discussed by Ausubel and Robinson (1969), Gagné (1970), and Klausmeier, Ghatala, and Frayer (1974). Each suggests that a major initial condition is that the concepts related in the principle must be attained before the principle itself can be meaningfully learned. Indeed, Gagné and Wiegand (1968) have demonstrated that once this initial condition has been met, very simple principles can be attained by merely presenting the principle statement and one illustrative example. However, when the principle to be learned is more difficult, additional instruction appears to be necessary (Anderson, 1970).

The present research was designed in part to investigate the type of instruction needed for the attainment of difficult principles. The major instructional variable focused upon was the use of a "rationally selected" set of examples and nonexamplesof the principle. This instructional variable was an extension of the idea of a "rational set" which has been found to be effective in concept learning (Klausmeier, Ghatala, & Frayer, 1974; Markle & Tiemann, 1969, 1972; Tennyson, Woolley & Merrill, 1972) to the area of principle learning.

It was hypothesized that:

1) Subjects instructed on the concepts contained in the principle would perform significantly better than subjects not receiving such instruction.

2) Subjects receiving a statement of the principle and either a rationally selected set of examples and non-examples or one example would perform significantly better than control subjects who did not receive a statement of the principle or any illustrative instances.

3) a. For a simple principle one example would be equally effective as a rationally selected set of instances if subjects received instruction on the concepts contained in the principle. If subjects did not receive instruction on the concepts, a rationally selected set would be more facilitative than one example.

b. For a difficult principle a rationally selected set of instances would be more facilitative than one example whether subjects received instructions on the concepts or not.

Method

Subjects

Subjects were 159 fifth-grade students, 81 females and 78 males, from a suburban community in south-central Wisconsin. They were judged to be of average ability and socioeconomic status. Reading achievement scores on the Metropolitan Achievement Test (Test F) which was administered during the fall of the school year were obtained for each child to be used as a covariate in analyzing the results of the study. The average achievement score was 78, which corresponded to a grade equivalency of

5.6. Subjects were randomly assigned within sex groups to an experimental condition.

Instructional Materials

Two principles from each of two subject matters (mathematics and language arts) served as the content of the learning task. On the basis of previous empirical research assessing a similar subject population's ability to answer questions based on these principles (Klausmeier, Sipple, & Allen, 1974 a, b), one principle from each subject matter was operationally defined as "simple" and the other as "difficult".

Two printed, sequential lessons were constructed to teach each principle. The first lesson presented the major concepts related in the principle using instructional procedures outlined by Klausmeier and Feldman (1975). This consisted of defining each concept at a level appropriate for fifth-grade students (the definition was set off in a box at the top of the page), illustrating each concept with a labeled rational set of examples and nonexamples (Markle & Tiemann, 1969) and emphasizing the relevant attributes of each concept by explaining why the examples were examples and the nonexamples were not examples.

In general, the concepts were presented in a random order and not in the sequence in which they occurred in the principle relating them.

Furthermore, no attempt was made to relate concepts to each other in any way except in cases in which the particular meaning of a concept necessitated the modification of one concept by another.

The four concept-teaching lessons were the same length in terms of number of pages (12 pages) regardless of the principle upon which they were based. This was done so that the lessons would take approximately the same length of time to complete and would appear to be as similar as possible to the subjects. As some lessons presented more concepts than others, the amount of material presented on each page could not be equated across lessons.

The second of the two sequential teaching lessons presented the principle itself. The principle was introduced at the top of the first page and was followed by either a rationally selected set of examples and nonexamples or by one example.

In order to construct the principle-teaching lessons the four principles were first analyzed in a manner similar to the way in which concepts are analyzed (Klausmeier, Ghatala, & Frayer, 1974). The principle was stated, and from the statement a list of relevant and irrelevant "attributes" was constructed. Relevant "attributes" were taken to be those aspects of the principle which were present in every correct demonstration, or example, of the principle. For

instance, in the principle "all equilateral triangles are similar in shape," the concept equilateral triangle is a relevant attribute. Irrelevant "attributes" were taken to be those aspects of the principle which either varied from example to example or did not have to be present in every example. For instance, the number of equilateral triangles used to illustrate "all equilateral triangles are similar in shape," or the size of the triangles, were considered irrelevant attributes.

On the basis of the list of relevant and irrelevant attributes a rationally selected set of examples and nonexamples was developed for each principle. Enough examples were specified so that all of the major irrelevant attributes of the principle were thoroughly varied. Enough nonexamples were specified so that each of the relevant attributes of the principle could be systematically excluded. Examples and nonexamples had similar irrelevant attributes.

All principle-teaching lessons that included a rationally selected set of examples and nonexamples were five pages long. In those lessons that included only one example three pages of placebo material were added so that all subjects would read treatment lessons of equal length. To compensate for any possible effects due to the order in which the placebo material was presented in relation to the principle and example

(principle and example followed by placebo material or vice versa), half of these booklets for each principle were prepared with the placebo material coming first and half with the placebo material coming last.

The examples used in the booklets which contained only one illustration of a principle were randomly selected from the rationally selected sets. To eliminate any effects due to the particular example chosen, several versions of these lessons were constructed for each principle and each version included a different example.

Two printed placebo lessons were also prepared that were equal in length to the two types of treatment lessons (concept teaching and principle teaching). The first placebo lesson dealt with concepts included in the definition of the concept tree. The second placebo lesson dealt with the concept Roman numerals.

Dependent Measures

A test on each of the four principles was constructed. The tests were structurally as similar as possible and varied among each other only in content.

Each of the four tests was sixteen items long and contained two types of questions: knowledge questions and application questions. Knowledge questions were items which required subjects to recognize both a statement of the principle and correct applications or examples of the principle. These items were designed to test subjects' ability to recognize or recall specific elements presented in the lessons. Application questions were items which required subjects to actually apply the principle in problem solving situations. These items were designed to test subjects' ability to go beyond the specific content of the lessons. An equal number of knowledge and application items were included on each dependent measure.

The four tests were presented in printed booklets similar in form to the lesson booklets. Instructions for completing the tests were included at the beginning of the booklets and were identical for all principles. Within the instructions were several sample items, one corresponding in form to each of the different types of question formats used on the tests (true-false type items and two multiple-choice forms).

Treatment Program

For each of the four principles taught, six treatment programs, or experimental conditions, were defined. Every subject was randomly assigned to both a treatment program and to a principle. Thus, each subject read materials dealing with only one principle and took the dependent measure on that principle alone.

The six treatment programs, which were identical across principles, were as follows:

CT-RS. Subjects read a concept-teaching lesson and a principle-teaching lesson. The principle-teaching lesson presented a rationally selected set of instances.

CT-1. Subjects read a concept-teaching lesson and a principle-teaching lesson. The principle-teaching lesson presented one example.

CT-0. Subjects read a concept-teaching lesson and a placebo lesson.

0-RS. Subjects read a placebo lesson and a principle-teaching lesson. The principle-teaching lesson (within a principle) was identical to that used in CT-RS.

0-1. Subjects read a placebo lesson and a principle-teaching lesson. The principle-teaching lesson (within a principle) was identical to that used in CT-1.

0-0. Subjects read two placebo lessons.

Procedure

Two experimenters working as a team conducted the study. One experimenter gave directions, distributed materials, and answered questions. The second experimenter distributed materials and answered questions only. In the majority of cases testing was done in the classroom with the classroom teacher present.

Subjects read the two treatment lessons and took the appropriate dependent measure during the same experimental session. At the start of the session a list of potentially difficult words contained in the lesson booklets was reviewed. Subjects were then allowed to read through the lesson booklets at their own rate. After completion of the lessons, the assessment tests were administered. Instructions for the tests and sample items were first reviewed aloud by the experimenter. Subjects then worked through the test booklets, again proceeding at their own rate. The entire experimental session lasted approximately one hour.

Results

Data from the two subscales of the assessment measures (knowledge and application items) were analyzed in separate 7x2x3x2x2 analyses of covariance. The covariate in each case was subject's reading achievement score. The five factors entering into the analysis were:

a. Instruction on concepts: instruction or no instruction

b. Type of principle: simple or difficult

c. Mode of principle presentation: principle statement with rationally selected set of instances, principle statement with one example, or no principle statement and no illustrative instances

d. Subject matter: language arts or mathematics

e. Sex.

Results obtained on knowledge items were disappointing. There was no significant effect for instruction on concepts or for number of instances used to illustrate the principle. The predicted interaction between type of principle, instruction on concepts, and mode of presentation was also nonsignificant.

The lack of significance on knowledge items seems to have been due to a ceiling effect. The mean score across all conditions was 6.642 (83.0% correct). It appears that subjects had some knowledge of the principles prior to experimentation.

Results on application items in general supported the predictions of the study. There was a significant main effect for mode of presentation with all means in the hypothesized direction. Subjects receiving a statement of the principle and a rationally selected set ($\bar{X}$=5.760) performed better than subjects receiving only a statement of the principle and one example ($\bar{X}$=5.345), who in turn performed better than control subjects who received no statement of the principle and no illustrative instances ($\bar{X}$=4.756). Pairwise comparisons among the means using a Scheffé procedure appropriate for analysis of covariance revealed that the group receiving a rational set performed significantly better than control subjects ($p < .05$).

Surprisingly, the main effect for instruction on concepts was not significant. Means were 5.302 for instruction and 5.315 for no instruction.

The interaction of interest, type of principle by instruction on concepts by mode of presentation, was marginally significant ($p < .07$). Means for the interaction are presented as Table 1.

Insert Table 1 About Here

Three comparisons among the means were carried out to test the specific hypotheses related to the interaction. The first comparison compared the effect of providing a rationally selected set with the effect of providing one example for simple principles when instruction on concepts was given (Hypothesis 3a, $_1 = \bar{x}_1 - \bar{x}_2$). The comparison was not significant ($t = -.7396$).

The second comparison contrasted the effect of providing a rationally selected set with the effect of providing one example for simple principles when instruction on concepts was not given (Hypothesis 3a, $_2 = \bar{x}_4 - \bar{x}_5$). This comparison was significant ($t = 2.3317$, $p < .05$).

The final comparison compared the effect of providing a rationally selected set with the effect of providing one example for difficult principles collapsed across instruction on concepts (Hypothesis 3b, $_3 = (\bar{x}_7 + \bar{x}_{10}) - (\bar{x}_8 + \bar{x}_{11})$. This comparison was also not significant ($t = .5742$).

It can be concluded on the basis of these three comparisons that providing a rationally selected set as compared to one example made little difference for difficult principles. However, there was a difference for simple principles, but only when no instruction on concepts was given, as had been predicted.

Discussion

Results on application items in general supported the predictions of the study. There was a main effect for mode of presentation with all means in the predicted direction. Post-hoc comparisons, however, revealed that only the group given a statement of the principle and a rationally selected set differed significantly from the control.

The interaction of interest between type of principle, instruction, and mode of presentation was found to be marginally significant for application items. An examination of the means for which specific hypotheses had been made revealed that for simple principles providing a rationally selected set of instances was significantly more effective than one example when subjects received no instruction on concepts, but made no difference when subjects did receive instruction. This finding was in line with the predicted results. However, no differences were found between a rationally selected set and one example for difficult principles.

An important difference in teaching strategy is suggested by the significance of this interaction and the significance of the main effect for mode of presentation. This is that without instruction on the concepts related in a principle a rationally selected set should always be provided; however, with instruction on concepts one example alone may be equally effective as a rationally selected set, but only if the principle to be learned is quite easy or simple.

The reasons why no difference was found between a rationally selected set and one example for difficult principles are unclear. Possibly the use of examples and nonexamples simply is not a sufficient or possibly even appropriate strategy when teaching difficult concepts. Further study is indicated.

A surprising finding was the lack of a significant main effect for instruction on concepts, as this contradicts the ideas of Gagné (1970), Ausubel and Robinson (1969), and Klausmeier, Ghatala, and Frayer (1974). Possibly subjects were already familiar with the concepts prior to experimentation. A more likely explanation, however, is that the deliberate absence of integration between concept-teaching and principle-teaching lessons rendered the information presented on the concepts difficult to utilize. Possibly instruction that is designed to integrate the concepts with one another as they are taught (perhaps by teaching the principle and the concepts simultaneously) would be more facilitative than the type of instruction provided in the present study. Indeed, in a follow-up

study I recently carried out (Vorwerk, 1975), results were obtained which seem to support this conclusion. When subjects were presented with instruction that integrated the concepts presented in a principle prior to presentation of the principle itself, the subjects performed better on a knowledge and application assessment measure than subjects who received instruction similar to the concept-teaching lessons presented here that included no integration.

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Table 1.

Adjusted Means, Adjusted Variances, and Cell Sizes
for Type of Principle by Instruction
by Mode of Presentation Interaction*

Application Items

		Mode of Presentation		
		Set	One Example	Placebo
Simple Principle	Instruction	1 5.237 (4.113) n=15	2 5.758 (5.290) n=14	3 4.351 (6.051) n=12
	No Instruction	4 6.354 (4.213) n=13	5 4.587 (5.071) n=12	6 5.089 (5.283) n=13
Difficult Principle	Instruction	7 6.100 (3.552) n=14	8 5.313 (3.477) n=14	9 4.861 (5.902) n=12
	No Instruction	10 5.453 (2.278) n=15	11 5.656 (2.817) n=12	12 4.698 (2.352) n=13

* $p < .07$